



**BREAST TUMOR EARLY DETECTION USING UWB ANTENNA AND  
IMPROVED FEATURE EXTRACTION TECHNIQUE**

by

**KHONDKER JAHID REZA**

**(1230810800)**

A thesis submitted in fulfilment of the requirement for the degree of Master  
of Science (Communication Engineering)

**SCHOOL OF COMPUTER AND COMMUNICATION ENGINEERING  
UNIVERSITI MALAYSIA PERLIS**

**2014**

DECLARATION OF THESIS

Author's full name : Khondker Jahid Reza

Date of birth : 15<sup>th</sup> January, 1987

Title : Breast Tumor Early Detection using UWB Antenna and Improved Feature Extraction Technique

Academic session : 2012-2014

I hereby declare that the thesis becomes the property of Universiti Malaysia Perlis (UniMAP) and to be placed in the library of UniMAP. This thesis is classified as:

- CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)
- RESTRICTED** (Contains restricted information as specified by the organization where research was done)
- OPEN ACCESS** I agree that my thesis is to be made immediately available as hard copy or online open access (full text)

I, the author give permission to the UniMAP to produce this thesis in whole or in part for the purpose of research or academic exchange only (except during the period of \_\_\_ years, if so requested above).

Certified by:

\_\_\_\_\_  
**SIGNATURE**

\_\_\_\_\_  
**SIGNATURE OF SUPERVISOR**

Khondker Jahid Reza (AA7203334)

Professor Dr. Sabira Khatun

\_\_\_\_\_  
**(NEW IC NO. / PASSPORT NO.)**

\_\_\_\_\_  
**NAME OF SUPERVISOR**

Date: \_\_\_\_\_

Date: \_\_\_\_\_

## ACKNOWLEDGEMENT

My deepest thanks to the Almighty Allah S.W.T. (Alhamdulillah), the Omnipotent, the Merciful and the Compassionate, for giving me the strength, patience and determination in compiling this research. Then, I would like to express my heartiest gratefulness to my beautiful family. I would like to thank specially to my supervisor, Professor Dr. Sabira Khatun for her valuable and constructive suggestions throughout this thesis that enabled it to run smoothly. I am very much indebted to my Co-supervisor Dr. Mohd. Faizal Bin Jamlos, for the guidance and lab facilities in my higher study. Also, Prof. Dr. R. Badlishah Ahmad provided excellent research facilities under the school of computer and communication engineering. I am deeply grateful to the Research and Development Department, Universiti Malaysia Perlis, Malaysia, for providing financial support for the Graduate Assistant (GA) Scholarship. I would like to share this moment of contentment and express the appreciations to my relatives who encourage at every step in my life. I owe a special gratitude to the Dr. Moslem Uddin Fakir and Bangladesh community in Perlis and in Pahang, Malaysia. Specially thankful to Md. Rubel Basar, Md. Ebne Al Ashad, Iftekhar Ahmed, Md. Anamul Islam, Md. Ashraf Ali, Wasib Bin Latif, Nayeem Morshed, Ilman Jais, Iszaidy Ismail, Md. Mostafijur Rahman and Md. Sobahan for their enormous support. Finally, I thank everyone else who has facilitated the making of this thesis, including other colleagues.

KHONDKER JAHID REZA

UNIVERSITI MALAYSIA PERLIS (UniMAP)

[jahid\\_rifat@yahoo.com](mailto:jahid_rifat@yahoo.com)

## TABLE OF CONTENT

	<b>Page</b>
<b>DECLARATION OF THESIS</b>	<b>i</b>
<b>ACKNOWLEDGEMENT</b>	<b>ii</b>
<b>TABLE OF CONTENT</b>	<b>iii</b>
<b>LIST OF TABLES</b>	<b>vii</b>
<b>LIST OF FIGURES</b>	<b>viii</b>
<b>LIST OF ABBREVIATIONS</b>	<b>xiii</b>
<b>LIST OF VARIABLES</b>	<b>xvi</b>
<b>ABSTRAK</b>	<b>xvii</b>
<b>ABSTRACT</b>	<b>xviii</b>
<b>CHAPTER 1: INTRODUCTION</b>	
1.1 Background	1
1.2 Motivation and Problem Statement of The Research	3
1.3 Aims and Objectives	6
1.4 Research Module	7
1.5 Brief Methodology	9
1.6 Organization of The Thesis	11
<b>CHAPTER 2: LITERATURE REVIEW</b>	
2.1 Introduction	13
2.2 Breast Cancer and Its Statistics	13
2.3 Conventional Breast Tumor Detection Techniques	16

2.3.1	Mammography	16
2.3.1.1	Drawbacks of Mammography	18
2.3.2	Magnetic Resonance Imaging	19
2.3.2.1	Drawbacks of Magnetic Resonance Imaging	20
2.3.3	Ultrasound	21
2.3.3.1	Drawbacks of Ultrasound	22
2.3.4	Digital Tomosynthesis	23
2.3.4.1	Drawbacks of Digital Tomosynthesis	24
2.3.5	Nuclear Imaging	26
2.4	UWB Microwave Imaging	27
2.5	Material Dielectric Properties and Phantom Preparation	28
2.6	Pattern Recognition	36
2.6.1	Neural Network	36
2.6.2	SVM classification	42
2.6.3	Feature Extraction	44
2.7	UWB Biomedical Antenna	45
2.8	Critical Review Highlights of Related Research	50
2.9	Summary	56

### **CHAPTER 3: ANTENNA DESIGN AND SYSTEM SETUP ISSUES**

3.1	Introduction	58
3.2	Antenna Design	58
3.3	System Model	64
3.4	Breast Phantom Preparation	69
3.4.1	Simulation Breast Model Preparation	69

3.4.2	Experimental Breast Phantom Preparation	73
3.5	Summary	76
<b>CHAPTER 4:    FEATURE EXTRACTION AND PATTERN RECOGNITION TECHNIQUES</b>		
4.1	Introduction	77
4.2	Pattern Recognition Methodology	77
4.3	Feature Extraction	81
4.4	Support Vector Machine	82
4.5	Neural Network	84
4.6	Summary	86
<b>CHAPTER 5:    ANTENNA PERFORMANCE RESULTS AND DISCUSSIONS</b>		
5.1	Introduction	87
5.2	Antenna Performances	88
5.3	Performance Investigation of Antenna $S_{11}$ Parameter	95
5.3.1	Tx Antenna Reflection Co-efficient Performances Through Air Media	96
5.3.2	Tx Antenna Reflection Co-efficient Performances Through Breast Model	98
5.3.2.1	Boundary Conditions in Near and Far Field Regions	99
5.3.2.2	Reactive Near Field Regions	106
5.4	Performance Investigation of Antenna $S_{21}$ Parameter	112
5.4.1	Tx Antenna Transmission Co-efficient Performances Through Air Media	112
5.4.2	Tx Antenna Transmission Co-efficient Performances Through Breast Model	114
5.4.2.1	Boundary Conditions of Field Regions	115
5.4.2.2	Reactive Near Field Regions	121
5.5	Summary	126

## **CHAPTER 6: PATTERN RECOGNITION PERFORMANCES**

6.1	Introduction	127
6.2	Support Vector Machine	127
6.3	Neural Network Performances Investigation	136
6.3.1	Using Proposed Feature Extraction	136
6.3.2	Using Proposed Antenna and Proposed Feature Extraction	144
6.4	Summary	148

## **CHAPTER 7: CONCLUSIONS**

7.1	Summary	149
7.2	Contributions	150
7.3	Future Study	151

<b>REFERENCES</b>	152
-------------------	-----

## **APPENDICES**

Appendix A: Parenthesis and their corresponding values.	168
Appendix B: ANN Validation Performances of Different Tumor Sizes	169
Appendix C: MATLAB Code	175
Appendix D: Publications and Achievements	178

## LIST OF TABLES

NO.	TITLE	PAGE
Table 2.1	Comparison in terms of tumor size, used centre frequency and number of antennas.	49
Table 3.1	Wavelength and their corresponding field boundaries.	66
Table 3.2	Considered values of $d_{TX}$ and $d_{RX}$ .	67
Table 3.3	Measured dielectric properties of tissues in various operating frequencies.	72
Table 3.4	Proposed dielectric properties of ducts in various operating frequencies.	73
Table 3.5	Dielectric properties of the used materials.	75
Table 3.6	Heterogeneous breast phantom mixed materials.	75
Table 4.1	NN model parameters.	84
Table 5.1	Corresponding antenna gain and directivity comparison with and without slot and notches conditions.	91
Table 5.2	Corresponding antenna gain and directivity comparison for different positions of reflector.	93
Table 5.3	Frequency range divisions.	100
Table 6.1	Confusion matrix.	128
Table 6.2	Confusion matrix of linear, quadratic, polynomial order 3 and rbf kernel functions.	130
Table 6.3	Confusion matrix of multi layer perception kernel functions.	133
Table 6.4	Training and validation performance efficiency of proposed feature extraction.	140
Table 6.5	Proposed feature extraction results comparison between proposed and previous works.	142
Table 6.6	Training and validation performances efficiency using both proposed antenna and Feature extraction.	146
Table 6.7	System performances comparison of using proposed antenna and previous commercial antenna.	147



## LIST OF FIGURES

NO.	TITLE	PAGE
Figure 1.1	Areas under study related to diagnosis methods.	8
Figure 1.2	Brief methodology flow diagram followed in this study.	11
Figure 2.1	Side view of the breast.	14
Figure 2.2	Age standardized incidence and mortality rates for breast cancer worldwide per 100,000.	16
Figure 2.3	Craniocaudal view of X-ray mammography.	17
Figure 2.4	X-ray Images for different density of breasts (a) low density (b) medium density (c) high density.	17
Figure 2.5	Magnetic resonance imaging.	20
Figure 2.6	MRI image with the detection of breast tumor.	21
Figure 2.7	Ultrasound system for breast tumor detection.	22
Figure 2.8	Digital Tomosynthesis machine breast check up.	23
Figure 2.9	Dual detector scintimammographic camera.	26
Figure 2.10	Performance of techniques.	28
Figure 2.11	Dielectric properties comparison of various tissues with varies ages (a) permittivity variation of normal breast tissues (b) permittivity variation of malignant tissues (c) conductivity comparison of normal breast tissues (d) conductivity comparison of malignant tissues (e) permittivity variation of normal breast tissues (f) permittivity variation of benign tissues (g) conductivity comparison of normal breast tissues (h) conductivity comparison of benign tissues.	30
Figure 2.12	Excised tissue from breast cancer surgeries. Malignant tissue and normal adipose tissue.	32
Figure 2.13	Quantified tissue properties found from normal diagnosis.	33
Figure 2.14	Heterogeneous phantom preparation at 3 GHz range.	34
Figure 2.15	Heterogeneous phantom preparation (a) 50 % Gland (b) 80% Gland.	35
Figure 2.16	ANN architecture example with one hidden layer.	37

Figure 2.17	Multiple NN nodes connected with weight.	38
Figure 2.18	Microwave radar based detection using 32 antennas.	47
Figure 2.19	4×4 planar UWB antenna for 3-D breast cancer detection.	48
Figure 2.20	UWB breast cancer imaging system.	52
Figure 2.21	Microwave radar based imaging system.	52
Figure 3.1	Cross sectional front view of proposed antenna (CST).	61
Figure 3.2	Cross sectional rear view of proposed antenna(CST).	61
Figure 3.3	Simulation $S_{11}$ result of the proposed antenna(using CST).	62
Figure 3.4	Front view of fabricated antenna without reflector.	63
Figure 3.5	Rear view of fabricated antenna without reflector.	63
Figure 3.6	Side view of fabricated antenna with reflector.	64
Figure 3.7	Theoretical system setup.	64
Figure 3.8	Near-field and far-field characteristics.	65
Figure 3.9	Simulation setup.	68
Figure 3.10	Experimental system setup.	69
Figure 3.11	Simulated breast model.	70
Figure 3.12	Breast tissue layers of simulation model.	71
Figure 3.13	Heterogeneous breast phantom preparation.	74
Figure 4.1	Proposed signal processing model for pattern recognition.	78
Figure 4.2	Experimental transceiver system setup.	79
Figure 4.3	P400 RCM hardware functional block diagram.	80
Figure 4.4	Ideal and scattered UWB waveforms.	81
Figure 4.5	Proposed neural network model.	85
Figure 5.1	Comparison of simulated vs. measured reflection coefficient ( $S_{11}$ ) for proposed antenna.	89
Figure 5.2	Comparison of antenna reflection co-efficient results in terms of slots and notches usage.	90
Figure 5.3	Comparison of reflection coefficient ( $S_{11}$ ) for various reflector positions (from 6.8 mm to 17.8 mm).	92

Figure 5.4	Directivity and gain of proposed antenna when reflector distance is 12.8 mm from the ground plane.	94
Figure 5.5	Far field polar plot of the proposed antenna (a) E-Field and (b) H-Field.	95
Figure 5.6	Simulated reflection co-efficient results comparison of proposed antennas in various positions without breast model.	97
Figure 5.7	Reflection co-efficient ( $S_{11}$ ) results of proposed antenna for various positions.	99
Figure 5.8	Simulation result comparison of reflection co-efficient maximum values for various positions of proposed antenna.	101
Figure 5.9	Experimental result comparison of reflection co-efficient maximum values for various positions of proposed antenna.	101
Figure 5.10	Simulation result comparison of reflection co-efficient minimum values for various positions of proposed antenna.	102
Figure 5.11	Experimental result comparison of reflection co-efficient minimum values for various positions of proposed antenna.	103
Figure 5.12	Simulation result comparison of reflection co-efficient average values for various positions of proposed antenna.	104
Figure 5.13	Experimental result comparison of reflection co-efficient average values for various positions of proposed antenna.	104
Figure 5.14	Simulation results of maximum reflection losses of proposed antenna for various distinct positions.	107
Figure 5.15	Experimental results of maximum reflection losses of proposed antenna in various distinct positions.	107
Figure 5.16	Simulation results of minimum reflection co-efficient values of proposed antenna for various positions.	108
Figure 5.17	Experimental results of minimum reflection values of proposed antenna in various positions.	109
Figure 5.18	Average reflection co-efficient ( $S_{11}$ ) simulation results of proposed antenna for various positions.	110
Figure 5.19	Experimental results comparison of average reflection co-efficient of proposed antenna for various positions.	111
Figure 5.20	Simulated reflection co-efficient results comparison of proposed antennas for various positions without breast model.	113
Figure 5.21	Transmission co-efficient ( $S_{21}$ ) values of proposed antenna for various positions.	114

Figure 5.22	Simulation results comparison of transmission co-efficient ( $S_{21}$ ) maximum values for various positions of proposed antenna.	115
Figure 5.23	Experimental results comparison of transmission co-efficient ( $S_{21}$ ) maximum values for various positions of proposed antenna.	116
Figure 5.24	Simulation results comparison of transmission co-efficient ( $S_{21}$ ) minimum values for various positions of proposed antenna.	117
Figure 5.25	Experimental results comparison of transmission co-efficient ( $S_{21}$ ) minimum values for various positions of proposed antenna.	118
Figure 5.26	Simulation results comparison of transmission co-efficient ( $S_{21}$ ) average values for various positions of proposed antenna.	119
Figure 5.27	Experimental results comparison of transmission co-efficient ( $S_{21}$ ) average values for various positions of proposed antenna.	119
Figure 5.28	Simulation results comparison of transmission co-efficient ( $S_{21}$ ) maximum values for various positions of proposed antenna.	122
Figure 5.29	Experimental results comparison of transmission co-efficient ( $S_{21}$ ) maximum values for various positions of proposed antenna.	122
Figure 5.30	Simulation results comparison of transmission co-efficient ( $S_{21}$ ) minimum values for various positions of proposed antenna.	123
Figure 5.31	Experimental results comparison of transmission co-efficient ( $S_{21}$ ) minimum values for various positions of proposed antenna.	124
Figure 5.32	Simulation results comparison of transmission co-efficient ( $S_{21}$ ) average values for various positions of proposed antenna.	125
Figure 5.33	Experimental results comparison of transmission co-efficient ( $S_{21}$ ) average values for various positions of proposed antenna.	125
Figure 6.1	(a) Training and (b) testing ROC graphs of linear, quadratic, polynomial order 3 and rbf kernel functions.	132
Figure 6.2	(a) Training and (b) testing ROC graphs of multi layer perception kernel functions.	135
Figure 6.3	(a) Validation performance (b) training state and (c) cross correlation between data points and curve fitting plots for 0.1cm tumor using proposed feature extraction.	139

Figure 6.4 (a) Validation performance (b) training state and (c) cross correlation between data points and curve fitting plots for 1 mm tumor using both proposed antenna and feature extraction.

145

© This item is protected by original copyright

## LIST OF ABBREVIATIONS

AI	Artificial intelligence
ANN	Artificial neural network
AWBU	Automated whole breast ultrasound
BT	Breast tomosynthesis
CAD	Computer -aided detection
CE-DBT	Contrast enhanced- digital breast tomosynthesis
CM	C-means
CMI	Confocal microwave imaging
CST	<i>Computer Simulation Technology</i>
CWT	Continuous wavelet transform
DAS	Delay-and-sum
DCT	Discrete cosine transform
DFT	Discrete fourier transform
DM	Digital mammography
DMIST	Digital mammographic smaging screen trail
FCC	Federal communications commission
FDTD	Finite difference time domain
FFDM	Full-field digital mammography
FFT	Fast fourier transform
FIT	Finite integration technique
GA	Genetic algorithm
GHz	Giga hertz
GRNN	General regression neural network
ICA	Independent component analysis

KHz	Kilo hertz
KSOM	Kohonen self-organizing map
LDA	Linear discriminate analysis
LMS	Least mean square
mm	Mille mitre
MHz	Mega hertz
MIMO	Multiple input multiple output
MIST	Microwave imaging space-time
MR	Magnetic resonance
MRI	Magnetic resonance imaging
MSE	Mean square error
NN	Neural network
PC	Principle component
PCA	Principle component analysis
PCB	Printed circuit board
PEM	Positron emission mammography
PET	Positron emission tomography
PFA	Principle feature analysis
PNA	Programmable network analyzer
PNN	Probabilistic neural network
RBF	Radial basis function
RCB	Robust capon beam forming
ROC	Receiver characteristic curve
RMS	Root mean square
RS	Rough set
SOM	Self organizing map
SVM	Support vector machine

TSAR	Tissue sensing adaptive radar
UWB	Ultra wide-band
WBAN	Wireless body area network

© This item is protected by original copyright



## LIST OF VARIABLES

$d_{Tx}$	Distance between transmitting antenna and breast model
$d_{Rx}$	Distance between receiving antenna and breast model
$T_x$	Transmitter antenna
$R_x$	Receiver antenna
$S_{11}$	Reflection co-efficient
$S_{21}$	Transmission co-efficient
$\epsilon$	Permittivity
$\bar{\sigma}$	Conductivity
$\mu$	Permeability
$w$	Weight vector
$b$	Bias
$k$	Kernel function
$E$	Error function
$y_n$	Actual output
$t_n$	Target output
$\zeta$	Slack variable
$R$	Field region
$D$	Diameter of antenna
$\lambda$	Wavelength
$\omega_o$	Frequency of oscillation
$\phi$	Cost function

## Pengesanan Awal Ketumbuhan pada Payudara Menggunakan Antena UWB dan Penambahbaikan Ciri Teknik Pengekstrakan

### ABSTRAK

Kanser payudara telah menyerang wanita dengan kejam di seluruh dunia. Ramai pesakit mempertaruhkan nyawa mereka setiap hari kerana kekurangan teknologi penyembuhan yang cekap dan sejumlah besar pesakit juga sedang berdepan risiko kematian. Pada masa ini, X-ray mammografi diiktiraf sebagai standard terbaik bagi pemeriksaan kanser payudara, tetapi ia mengalami nisbah kesalahan pengesanan yang tinggi, kesakitan mampatan payudara dan lain-lain kesan sampingan yang berbahaya. Tujuan utama kerja-kerja ini adalah untuk mengenal pasti tumor dalam saiz yang kecil dengan menggunakan kaedah pengesanan yang cekap, mesra pengguna dan bukan kaedah pemedahan tanpa kesan sampingan ke atas kesihatan manusia. Untuk mencapai tahap itu, *microstrip patch ultra Wideband* (UWB) antena berbentuk piramid dicadangkan untuk diantara frekuensi 3.23 GHz hingga 12 GHz untuk berasaskan radar sistem pengimejan gelombang mikro. Prestasi antena diukur dalam medium udara dan juga di sekitar model payudara untuk band teknologi UWB yang lebih rendah (3 GHz ke 6 GHz). Dalam kedua-dua kes, antena dan pantulan ( $S_{11}$ ) dan penghantaran ( $S_{21}$ ) pekali diuji dalam medan dekat dan jauh. Ujikaji dan model payudara realistik juga direka menggunakan perisian *Computer Simulation Technology* (CST). Jarak ( $d_{Tx}$ ) di antara pemancaran (Tx) antena dan model payudara diubah dari 1 mm sehingga 36 mm. Keputusan menunjukkan bahawa, antena Tx lebih baik di rantau reaktif berhampiran pada  $d_{Tx}$  1 mm hingga 10 mm dari model payudara. Maksimum dan minimum kehilangan penghantaran direkodkan ialah -63.74 dB dan -9.5 dB masing-masing pada jarak 36 mm dan 1mm. Sebaliknya, kehilangan pantulan maksimum dan minimum yang dicatatkan adalah -1 dB dan -52.58 dB masing-masing pada 36 mm dan 2 mm. Berdasarkan keseluruhan eksperimen, penerima diletakkan secara tetap pada 1mm dari payudara dan isyarat yang diterima disimpan untuk pemprosesan isyarat selanjutnya. Satu teknik pengekstrakan cekap dicadangkan. Ia juga meningkatkan rangkaian latihan dan kecekapan ujian neural dengan mengurangkan tempoh masa yang diperlukan. Prestasi keseluruhan sistem disahkan dengan menggunakan dicadangkan pengekstrakan ciri dan antena yang dicadangkan untuk saiz tumor berbeza. Kajian perbandingan antara fungsi kernel *support vector machine* (SVM) termasuk fungsi *linear*, fungsi asas jejarian, polinomial dan persepsi berbilang lapisan dikaji dan dibuktikan untuk pengiktirafan prestasi corak dengan ketepatan 100 %. Tetapi SVM mengesan saiz tumor dengan ketepatan lebih rendah berbanding dengan keputusan *artificial neural network* (ANN). Secara keseluruhan sistem ini dapat mengesan kemujudan tumor bersaiz 1 mm (diameter) dengan ketepatan kira-kira 99% iaitu 3.2% lebih tepat berbanding sistem sedia ada.

## Breast Tumor Early Detection using UWB Antenna and Improved Feature Extraction Technique

### ABSTRACT

Breast cancer has already invaded the women around the world with its brutal attack. Numerous patients are sacrificing their lives everyday due to lack of efficient cure technology and a huge number of patients are still existing to hear the death sentence. X-ray mammography is currently recognized as the golden standard of breast cancer screening, but it suffers from high miss detection ratio, painful breast compression and other harmful side effects. The main motto of this work is to identify the tumor in its smallest dimension using an efficient, user-friendly and non-invasive detection method without any side effects on human health. Towards this goal, a pyramidal shaped microstrip patch ultra wideband (UWB) antenna is proposed for frequency range of 3.23 GHz to 12 GHz for radar based microwave imaging system. The performance of the antenna is measured in air media as well as in the vicinity of breast model for lower band (3 GHz to 6 GHz) of UWB. In both cases, the antenna's reflection ( $S_{11}$ ) and transmission ( $S_{21}$ ) coefficients are investigated in near field and far field region. A realistic breast model is also designed through *Computer Simulation Technology* (CST) software and experimentally. The distance between the transmitting antenna and breast model is varied from 1 mm up to 36 mm. The results show that, the proposed antenna performs better in near reactive region at a distance of 1 mm to 10 mm. Maximum and minimum transmission losses are -63.74 dB and -9.5 dB at 10 mm and 1 mm distance respectively. On the other hand, maximum and minimum reflection losses are found -1 dB and -52.58 dB at 36 mm and 2 mm respectively. In the whole experiment, the receiver is kept fixed at 1 mm apart from the breast and the received signals are reserved for the further signal processing. An efficient feature extraction technique (i.e., maximum, minimum, mean and standard deviation amplitude values of received pulse) is proposed here which also enhances the neural network training and testing performances by reducing the required time duration three times than previous studies. The overall system performance is verified by using proposed feature extraction and proposed antenna for various tumor sizes. The comparative study among support vector machine (SVM) kernel functions including linear function, radial basis function, polynomial and multi layer perceptions are investigated and verified for pattern recognition performance with 100% accuracy. SVM detects tumor size with lesser accuracy than artificial neural network (ANN) results. The overall experimental system with ANN is able to detect tumor existence and tumor size of 1 mm (diameter) with nearly 99 % accuracy, which is around 3.2% more than related existing systems.

# CHAPTER 1

## INTRODUCTION

### 1.1 Background

Breast cancer is a fatal disease among the women all over the world. It is recognized as the second deadly cancer after the lung (United States Cancer Statistics, 2010). Researchers are studying more and more to figure out the reason behind this deadly disease. It may appear that, abnormal cell division of the breast tissues usually occurs either in lobules (milk producing tissue) or in ducts (connecting tissue between lobule and nipple). This abnormal cell division forms mass or lump that is called tumor. There are two types of tumors: benign and malignant. Usually, tumors are benign but with the passage of time, it turns into the deadly cancer called malignant tumor. In a recent survey from American cancer society (American Cancer Society 2012), it is found that 89% of women could survive if the cancer is detected within 5 years, this is also known as early detection. This rate may reduce to about 82% and 77%, if it is detected after 10 years and 15 years respectively. The researches show that early detection is prerequisite for the long term survival (Joy et al., 2005; Taber et al., 2003). To the best of author's knowledge, at present there is no cure method exists in the universe. There are very few available detection techniques to detect breast tumor in early stage. Most of the existing detection techniques have two major shortcomings, which are hazardous to human body and unable to detect in early stage. At present, X-ray mammography is recognized as the golden detection technique for breast cancer (Tabar et al., 2010). This method has some bad effects on human health. Firstly, the

required breast compression for the test is painful and harmful to the patient. Secondly, the ionization effect of the mammography may destroy the surrounding healthy breast tissues. Study shows that the mammography may have the miss detection ratio up to 30% (Huynh et al., 1998). Several studies reveal that mammography is more suitable for the non-dense breast rather than the other types. So, it is not a wise approach for woman less than 30 years of old (Saslow et al., 2007) and that is why researchers are looking for a subsidiary option. Ultra sound technology may be a good solution for this issue. This technology uses the ultra sound for detection of breast tumor. But this technique produces very low sensitivity signal. This poor sensitivity may hamper and blur the image quality of the test and confuse physiologists during check-up (Kaplan et al., 2001; Crystal et al., 2003).

Nuclear methods are already introduced for breast cancer detection whereas positron emission mammography (PEM) and positron emission tomography (PET) are mostly used techniques. The most challenging part of this method is the handling risk of nuclear materials. This method is efficient to detect the cancer with some side effects on human body, but frequent use of this technology become hazardous to human body. Microwave imaging has extensively been introduced for biomedical applications. The advantage of this technology having less side effect to human health. Ultra wideband (UWB) technology is one of them and suitable for early detection of breast cancer. It's low power transmission and object detecting capability attracts the researchers to utilize this technology for biomedical applications. According to Federal Communications Commission (FCC), the allocated frequency range for the UWB technology is 3.1 GHz to 10.6 GHz (FCC, 2002). The basic principle of UWB breast imaging is the dielectric

properties discrepancy between cancerous and healthy breast tissue. The cancerous tissues scatter more signal imposed on it than normal tissues (Farhang et al., 2008).

Various UWB system design techniques have already been proposed and some others are currently under investigation. Microwave tomography is formed of several UWB antennas where one antenna radiates the UWB pulses and rest of the antennas receive the scattered pulse from the object (Diaz-Bolado et al., 2011; Irishina et al., 2007). Unlike tomography, radar based microwave imaging consists of a transmitter and a receiver UWB antennas, where transmitter antenna emits UWB pulses at a time towards breast phantom and captures the scattered signal (by itself or other receiving antennas) (Fear et al., 2000). In this study, the recorded UWB pulses are forward scattered from the breast model, which is similar to the system proposed by Alshehri et al. (2009).

## **1.2 Motivation and Problem Statement of The Research**

Regular breast check-up is necessary and recommended by expert doctors for women community. Usually, people are reluctant to go for clinical check-up unless they feel physical problem. This is a common human nature to reduce hassle and cost.

Breast is an organ where abnormalities (tumors/cancer) can crop easily and silently due to its tissue structure. In general, benign tumor may exist longtime inside the breast tissue without (showing or feeling) any symptom to the patient. But the situation may become worst whenever it turns to deadliest malignant tumor rapidly. So, it is urged to develop a user friendly, handy, low-cost and automated non-invasive

system for end users (domestic environment) for their breast self-checkup regularly and for early detection of breast tumor.

The existing systems are mostly operator dependent, complicated, heavy and implemented for clinical purposes only. None of the study has yet been done thinking about the end user for domestic usage. The feature of the proposed system includes simple, cost efficient, highly accurate, non-invasive and user friendly which can be used for household applications.

Microwave UWB imaging poses new challenges for early breast tumor detection. It requires a high resolution characteristics that can be achieved from the transmitting/receiving antenna. The desired antenna should have compact size, low distortion, and high directivity and gain (Abbosh et al., 2009; Adnan et al., 2010). But, the antennas so far designed for the microwave imaging system are not handy and have computational complexity with a less directive gain (Tiang et al., 2013). Some researches on antenna design (especially on UWB antenna) for breast tumor detection have also been done (Bourqui et al., 2010; Yu et al., 2009). These research works tend to design planar and small size UWB antennas since those are easy to implement as a base for an antenna array with several elements (Kanj et al., 2008). Also, the antenna size is comparatively large for household usage (Zhang et al., 2005). Towards the design of a handy, cost effective and having less computational complexity microwave imaging system, Alshehri has already proposed early breast tumor detection system using couple of transceiver antennas (Alshehri et al., 2009). But a set of commercial transceiver (Tx) and receiver (Rx) antennas were being used in Alshehri et al. study which may deteriorate the signal strength and directive gain. Therefore, the goal of this

research is to develop a compact sized, low cost and bio-friendly UWB planar antenna suitable for cost effective, easily usable and handy breast tumor detection system.

For the development of the proposed system, some crucial factors also come in to account which are not defined in the previous microwave imaging studies. The facts are to chose optimum operating frequency and placement of transmitting (Tx) antenna from the breast tissue. So far, from previous researches it is not clear what type of scattering (i.e., forward or backward) suitable for tumor detection at a particular Tx antenna distance from breast model (denoted as  $d_{Tx}$ ) over a certain frequency range. For dispersive tissue wave propagation, Tuovinen et. al. (2012) have investigated the reflection loss co-efficient ( $S_{11}$ ) result for UWB planar antennas. In their study, radiating and reactive near field results are compared between dipole antenna and loop antenna. The position of both antennas is varied from the 0 mm to 30 mm. The diameter of their designed antennas are large enough for body propagations, but they did not measure transmission co-efficient,  $S_{21}$  to verify clearly the antenna performances. Also, the discrete ports used for their case is not realistic and practically implementable.

On the other hand, signal processing algorithms are used to usually process, digitize and analyze the received signal and detect the existence of any tumor tissues (if exists). The extracted featured signal values and pattern recognition are then processed for classifications. There exists a good number of pattern recognition methods for the received UWB pulses. Support vector machine (SVM) detection technique has already been used to classify only the tumor signature from mammographic image (Ireaneus et al., 2009). SVM does have remarkable performance in terms of classification between tumor affected and healthy breasts tissues (Zhi-Hang et al., 2013). But there exists a